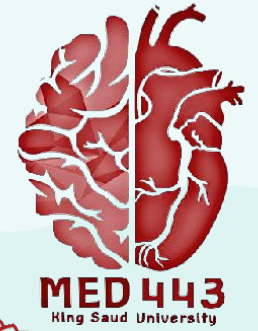
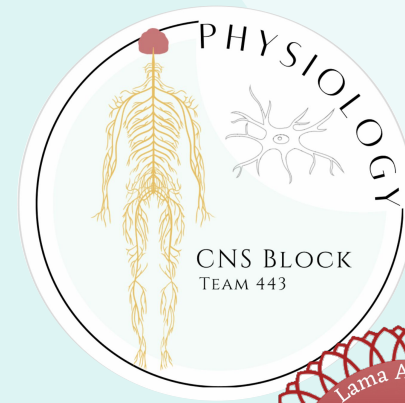




# Physiology of the eye & refraction



## Color Index:

- Main text
- **Important**
- Girls Slides
- Boys Slides
- Notes
- Extra

[Editing File](#)



## Objectives...

- 1-To Describe different components of the eye and function of each .
- 2- Describe the refraction of light as it passes through the eye to the retina
- 3-Identifying the refractive media of the eye
- 4- Know fluid system of eye & glaucoma and binocular vision
- 5- Know layers of retina, blind spot, and fovea
- 6- Know principles of optics and errors of refraction
- 7-Light pathway in the eye
- 8-explain the different light sensitivities of the fovea, peripheral retina and optic disk
- 9-Know layers of retina, blind spot, and fovea centralis



# Eye.....

## EYE HAS:-

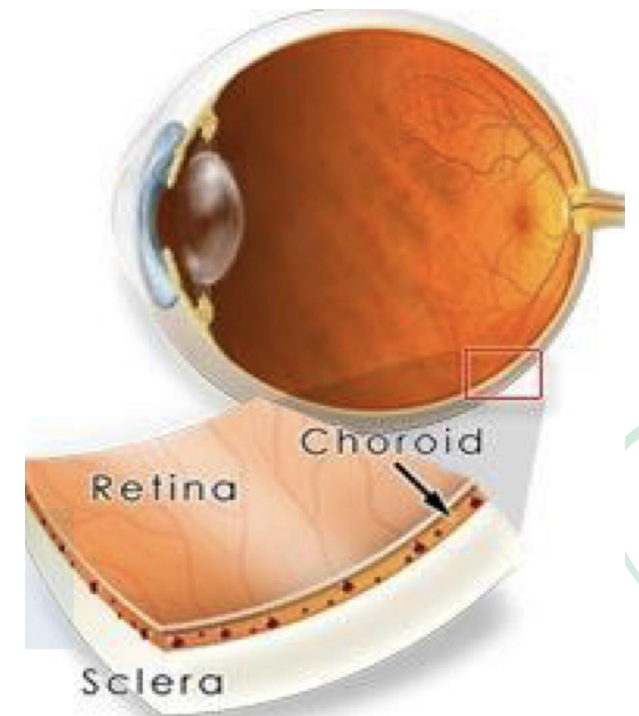
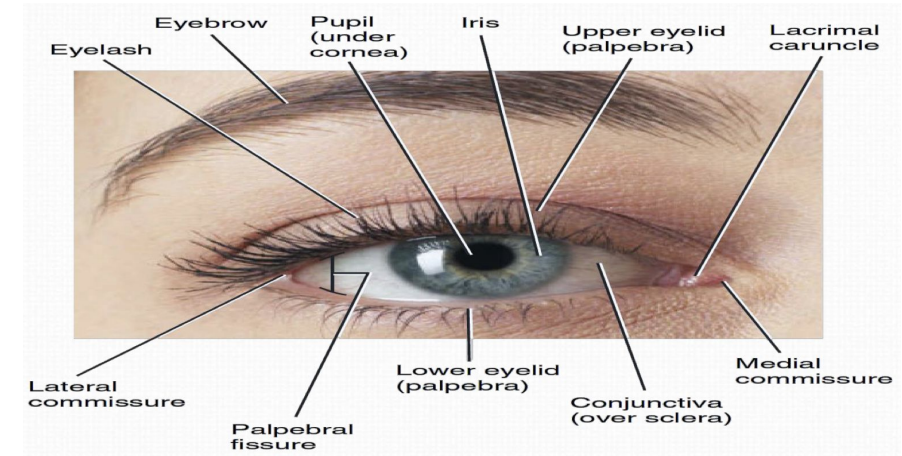
- 1- Refracting Media
- 2- Coats (Sclera, Choroid and Retina )

Human vision is one of the most complex visual systems among animals.

The eye is a complex sensory organ, which capable of **transduction physical stimuli of light rays into electrical** and chemical signals that can be interpreted by the brain to construct physical images.

The eye is a fluid-filled sphere enclosed by three specialized tissue layers.

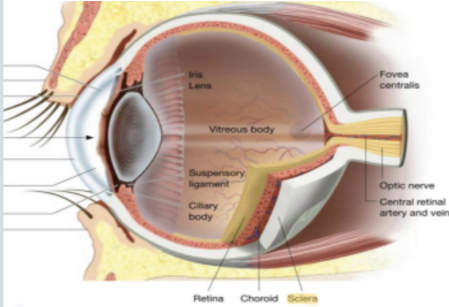
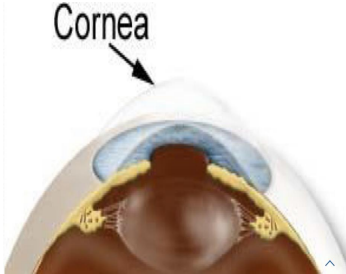

- 1- the sclera is a tough outer covering of connective tissue.
- 2- the middle layer is the choroid containing blood vessels.
- 3- the retina is the innermost layer which contains light sensitive cells





# Anatomy of the eye

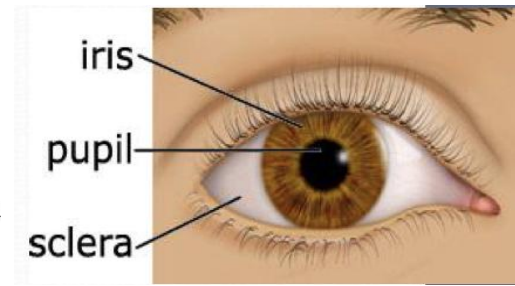
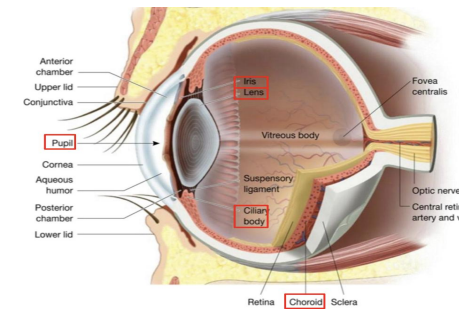
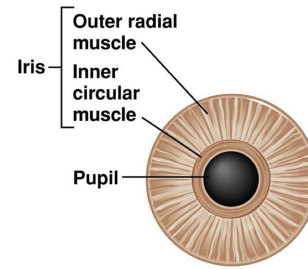
## 1 Outer Fibrous layer

<b>Sclera</b>	<p>thick, white fibrous tissue for protection- spherical appearance</p>	
<b>Cornea</b>	<p>modified anterior 1/6 of sclera to allow light to enter the eyes. it is transparent anterior portion, avascular. - Refractive or dioptric power 40-45 D at its anterior surface. Q.From where it gets its nutrition? A/ Tears &amp; aqueous humor</p>	
<b>Conjunctiva</b>	<p>Transparent membrane/epithelium, lines and covers the sclera/ anterior surface of eye, reflected on inner surface of eyelids and Covered with thin film of mucus and tears for protection, wetness and cleaning./prevent entrance of microbes and dust into the eye,</p>	



# Anatomy of the eye

## 2 Middle layer



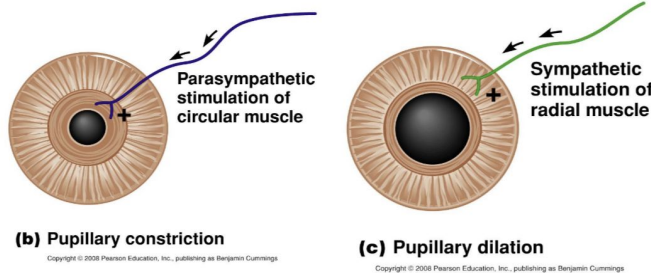
<p><b>1-Choroids</b></p>	<p>-inside sclera , highly vascular structure          -the capillaries in the choroid are the primary source of nourishment for retinal photoreceptors &amp; oxygen to rods and cones          -post 2/3 of choroid has retina (innermost layer lining)          The outermost layer of the retina depends mostly on diffusion from choroid blood vessels for nutrition specially oxygen supplying</p>
<p><b>2-Iris</b></p>	<p>Colored part of the eye, Has aperture (pupil) control &amp; allow light to enter the eye.          Has the papillary muscles.</p>
<p><b>3-pupil</b></p>	<p>behind center of cornea, control &amp; allow light to enter the eye, appears black because, as you look through the lens, you see the heavily pigmented back of the eye (choroid and retina)</p>
<p><b>4- Ciliary muscles (body)</b></p>	<p>Thick anterior part of choroid to which attached to suspensory ligaments (zonule) attached to the lens          Ciliary body consists of: Ciliary muscles, Ciliary glands</p>
<p><b>5- Lens</b></p>	<p>Transparent, biconvex, semisolid, dioptric power 15-20 D, held in place by zonule = lens ligament = suspensory ligament) attached to anterior part of ciliary body within the cells of the lens, proteins called crystallins are arranged like the layers of an onion, this makes up the refractive media of the lens          -Lens helps focus images on the retina to facilitate clear vision.</p>
<p><b>6- Uvea</b></p>	<p>= choroid + iris + ciliary muscles</p>



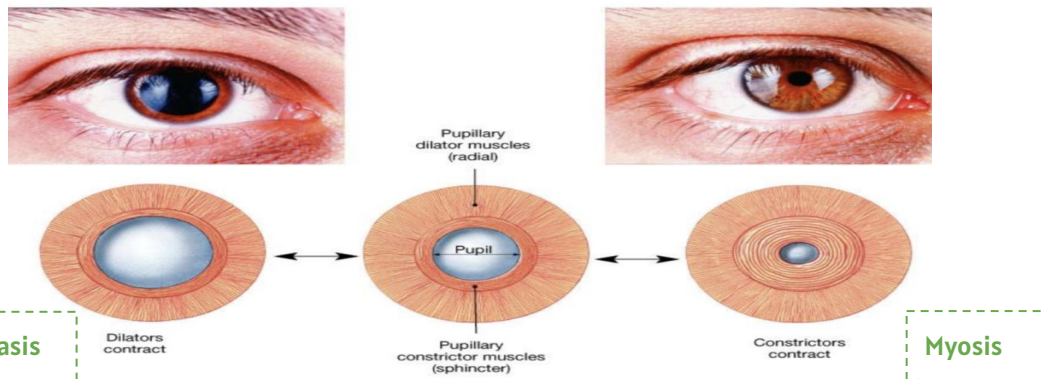
# Anatomy of the eye

## The pupillary muscle consists of:

- 1- radial muscle dilates the pupil as in dim light supplied by sympathetic mydriasis
- 2- constrictor pupillae (circular muscles) constrict the pupil by parasympathetic as in bright light. Myosis



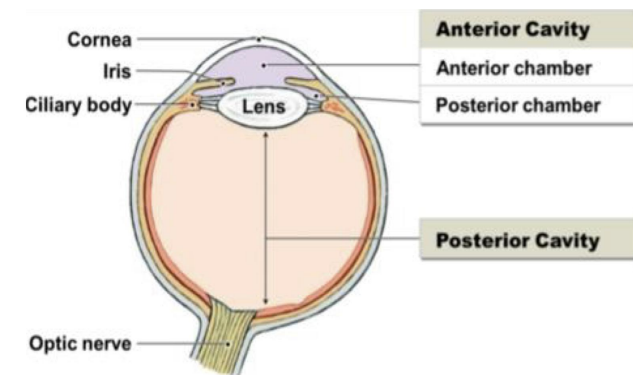
The Pupillary Muscles: consists of → Radial and Circular parts



## The Anterior & Posterior Cavities:

- The Ciliary Body, suspensory ligament and lens divide the eye into :

<b>Anterior cavity</b>	which contains a fluid called <b>Aqueous Humor</b> . Anterior cavity divided by iris into 2 more chambers:-	a)Anterior Chamber, between iris and cornea	b)Posterior Chamber, between iris and lens.
<b>Posterior cavity</b>	which contains fluid called <b>Vitreous Humor</b>	-	-





# Anatomy of the eye

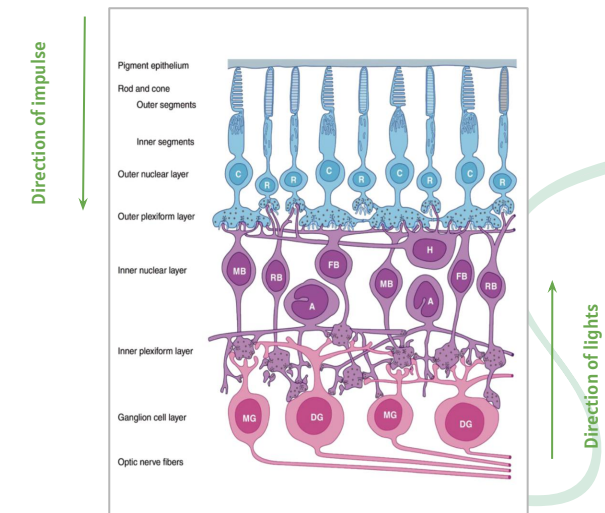
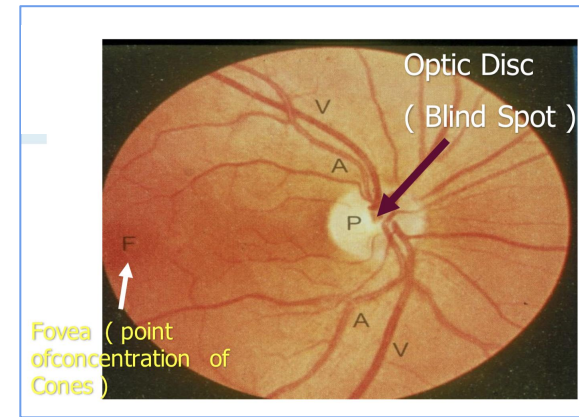
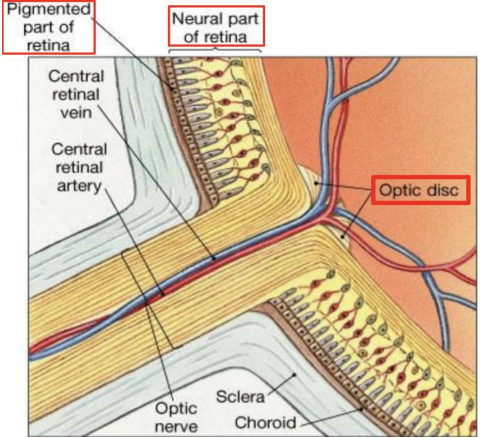
## 3 INNERMOST LAYER RETINA

Consist of:

1-Outer pigmented portion ( part ) it's function are:

- A- Absorb light & prevent its reflection back
- B- Store Vit A

2 -Inner neural part , containing **Photoreceptors called Rods and Cones** .



1- Photoreceptors

- A) Rods: are best for vision in dim light (**scotopic vision**).
- B) Cones: are best for vision in daylight or bright light (**photopic vision**), color vision (color perception) & perception of detail (acuity of vision).

2- OPTIC DISC

- ( blind spot. Why?)
- 3mm medial & above post pole of eye
- optic nerve leave & retinal blood vessels enter
- (no photoreceptors so it is blind spot)

3- **MACULA** & **FOVEA CENTRALIS**

- An important part of the retina is the **Macula Lutea** .
- At the center of the Macula we find the **Fovea Centralis**
- Depression or spot inside macula lutea , yellow pigmented at post pole of eye
- for colors vision & details detection
- high visual acuity
- In the **Fovea** we find the maximum concentration of cones → consequently → the **Fovea** is the point of maximal visual activity in the retina .
- Contain only **Cones** are densely packed at the **Fovea** .
- When you turn your eye to look at an object → you tend to place its image in the **Fovea**



# Disorders of the Eye and Vision: Retinopathy



## Retinopathy in diabetes

- Vessels have weak walls – causes hemorrhaging and blindness







# Layers of Retina & Retinal Cells

There are five basic classes of neurons in the retina

Photoreceptors

Bipolar cells

Horizontal cells

Amacrine cells

Ganglion cells

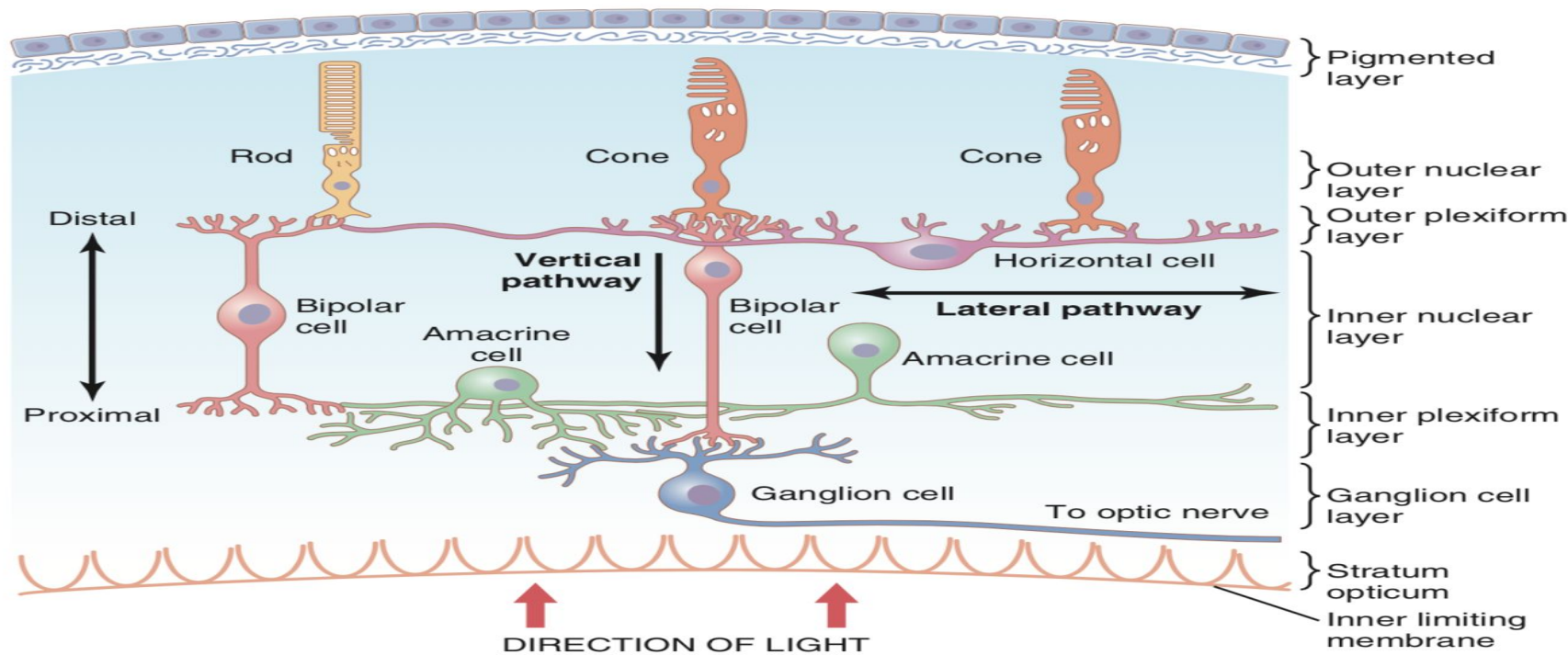


Figure 51-1. Layers of the retina.



# Layers of Retina & Retinal Cells

Layers of retina (10 layers), the most important are

	Layer	Type of Cells & features
Outer	Pigment cell layer (Vit A)	Outermost layer (absorb light & prevent its reflection back). The pigment layer also stores large quantities of vitamin A an important precursor of the photosensitive chemicals( Rhodopsin)of the rods and cones.
	Rods & Cones	Their outer & inner segments, but not cell bodies. (Rodes 90-120 million & cones 4.5- 6 million) (Cones concentrated in fovea centralis and rods concentrated on the peripheries) photoreceptor cells are responsible for capturing light and transforming this into generator potential be used by the nervous system .
	Outer nuclear layer	Cell bodies of Rods & Cones.
	Outer plexiform layer	mainly of Horizontal cells.
	Inner nuclear layer	Bipolar cells.
	Inner plexiform layer	Amacrine cells. Interposed between the inner nuclear and ganglion cell layers.
	Ganglion cell layer	The axons of ganglion cells form the optic nerve
Inner	Optic nerve fibers	1.2 million fibers. Horizontal cells (outer plexiform layer) make synaptic connections with receptors. Amacrine cells (inner plexiform layer) make synaptic connections with ganglion cells.



# External protection of the eye.

- 1 Bony orbit
- 2 Eyelids with their lashes (Eyelids blinking keep cornea moist)
- 3 Conjunctiva
- 4 Tears from lacrimal gland:
  - has antibacterial, lubricating effect
  - keep cornea moist & clear
  - **provide nutrition to the cornea** (because it's avascular)

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## Lacrimal Apparatus

Lacrimal gland

Superior and inferior canaliculi

Lacrimal sac

Nasolacrimal duct

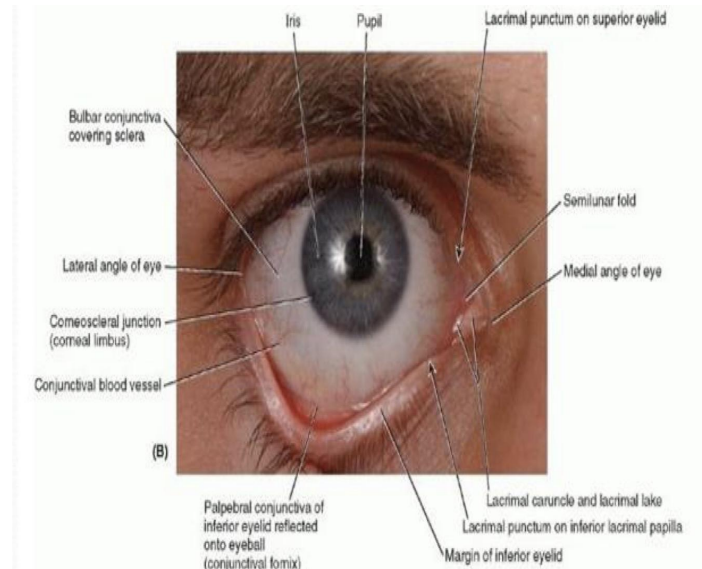
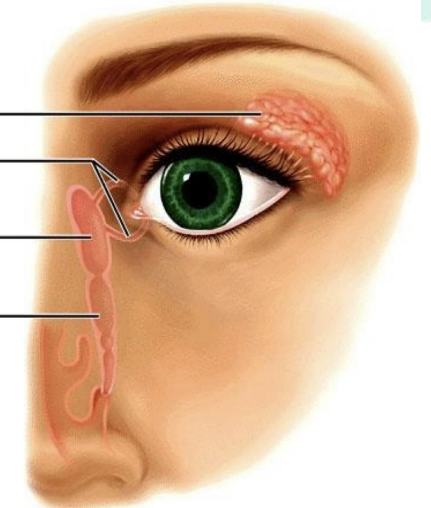


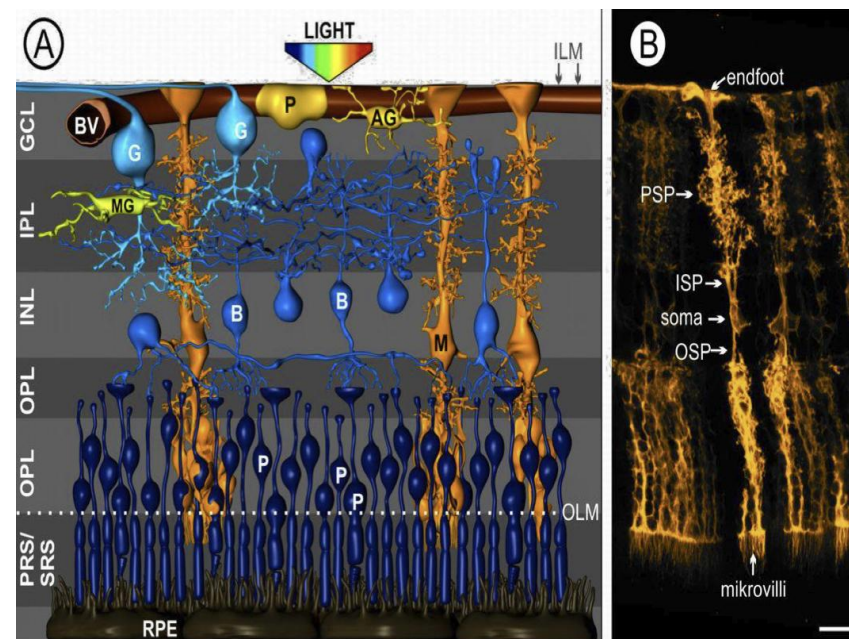
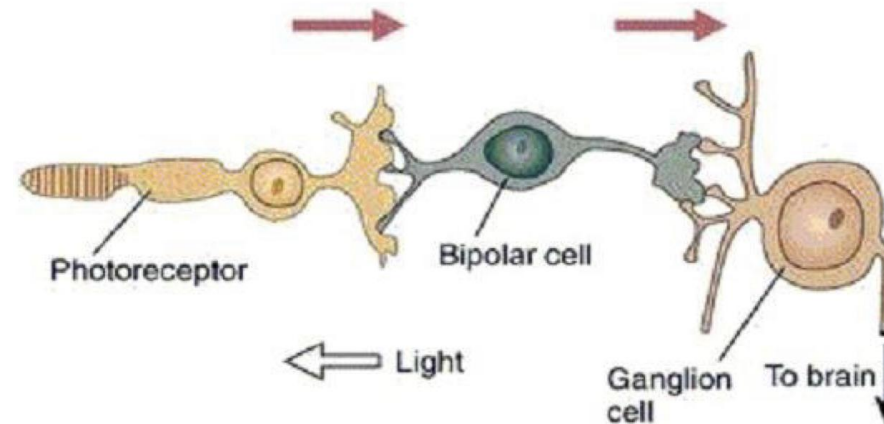
FIGURE 7.64. Surface anatomy of the eye (A) and lacrimal apparatus (B).

# Retinal neural circuits

Light hits photoreceptors, sends signal to the bipolar cells then to ganglion cells

Müller cells are the major glial element of the retina.

- located in the inner nuclear layer
- providing metabolic support to retina
- maintaining synaptic levels of neurotransmitters.
- act as light conduction



Müller cells are shown in orange



# Light pathway in the eye:

After light passes through the lens system of the eye and then through the vitreous humor

before it finally reaches the layer of rods and cones located on the outer edge of the retina

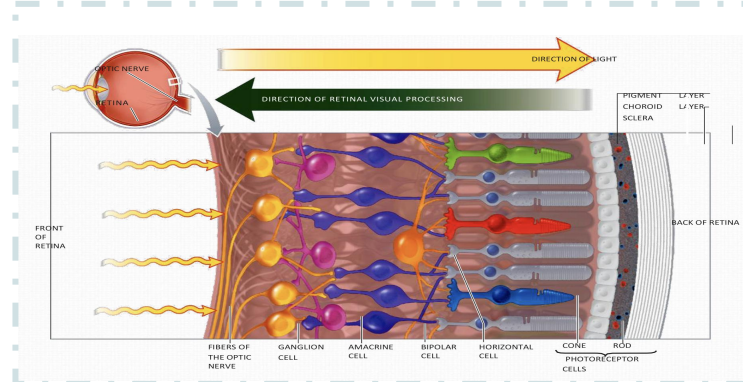
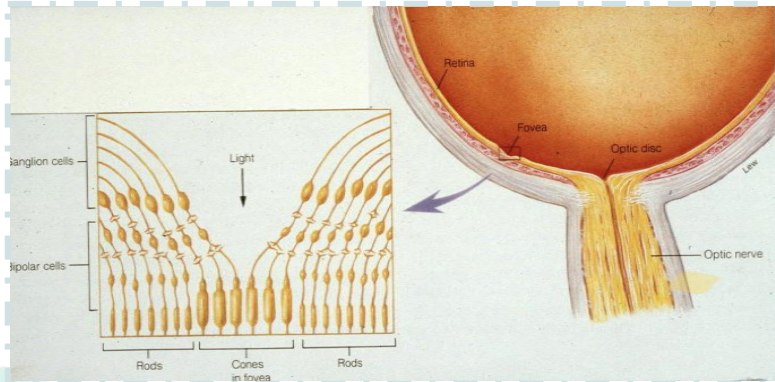
finally to ganglion cell layer to optic nerve



it enters retina -it passes first through the ganglion cells and then through the plexiform and nuclear layers

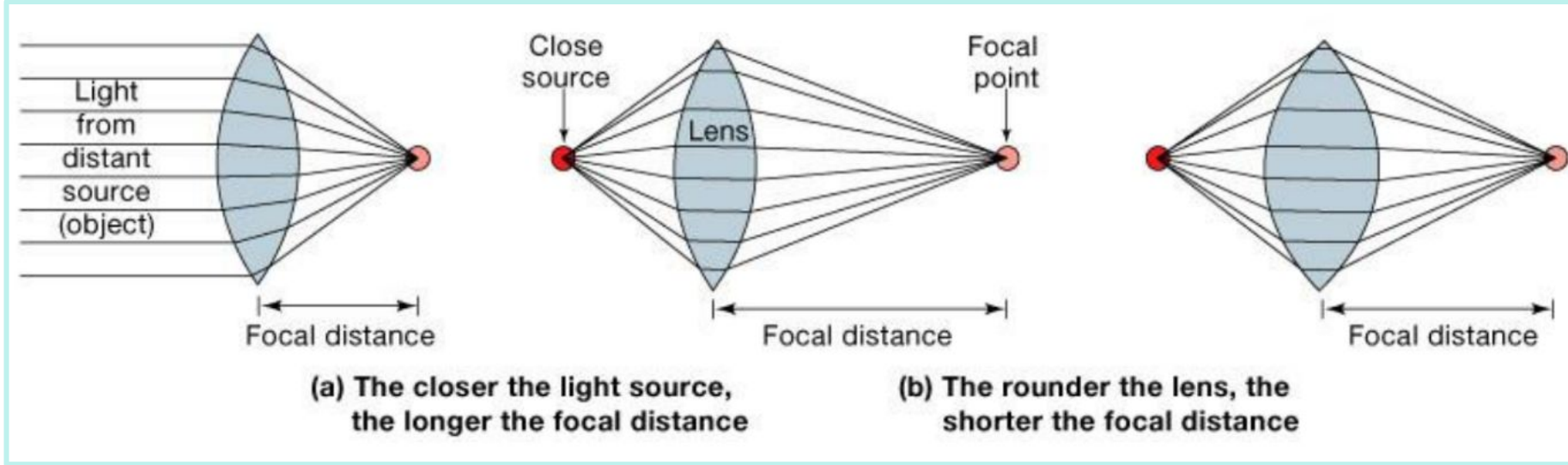
Light absorbed by pigment cell layer contain melanin pigment - then to rods& cons then impulses pass from them to rest of layers

this picture is also in male slides. explanation: the layers of the retina gets pushed aside, so lights go down directly to cones. this is one of the reasons that fovea is an area with maximal visual acuity





# Lenses: Principles of Optics



Focal point: منطقة تجمع الضوء

Focal distance: المسافة بين نقطة تجمع الضوء و العدسة

الأشعة التي تأتي من مسافة بعيدة تكون (Parallel) فتجميعها سيكون سهل عشان كذا بتكون ال (distance focal) قصيرة الأشعة التي تأتي من مسافة قريبة تكون (divergence) فتجميع الضوء سيكون صعب وبيحتاج إلى مسافة عشان كذا يكون تجميعها صعب وال (focal distance) طويلة ، لكن عدسة العين كل ما صارت دائرية أكثر كل ما كان تجمع الأشعة أقرب وال (focal distance) أقصر



# Lenses: Principles of Optics

## Image Forming mechanisms:

### Principle focus:-

parallel rays strike biconvex lens refracted in a point is PF.

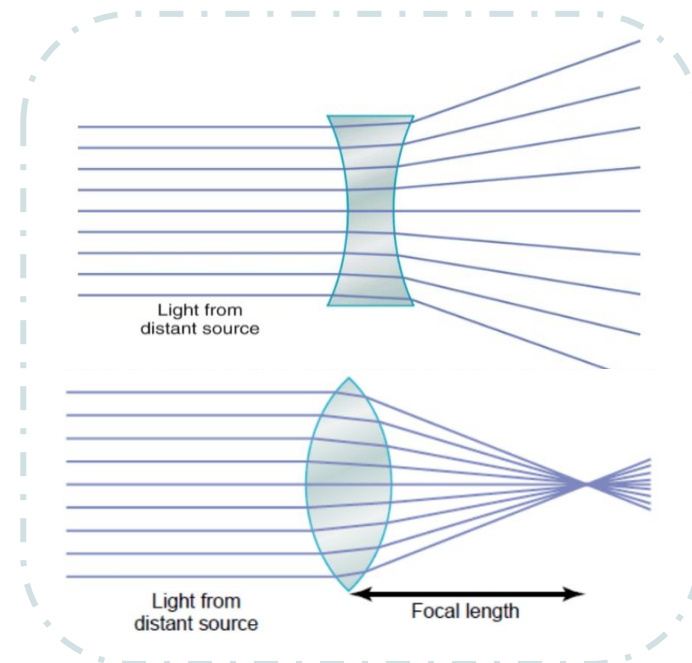
### Principal axis:-

PF lies on line pass through centers of lens curvatures

### Principal focal distance:

distance between lens & PF.

- Lens to Retina distance = 17mm, 15mm.
- Biconvex Lens (converge) & biconcave lens (diverge)
- Dioptric power of the eye:
  - Cornea 40-45 D
  - Lens 15-20 D
  - Accomodation by lens +12 DIt can add 12 D depending on the distance of the body.



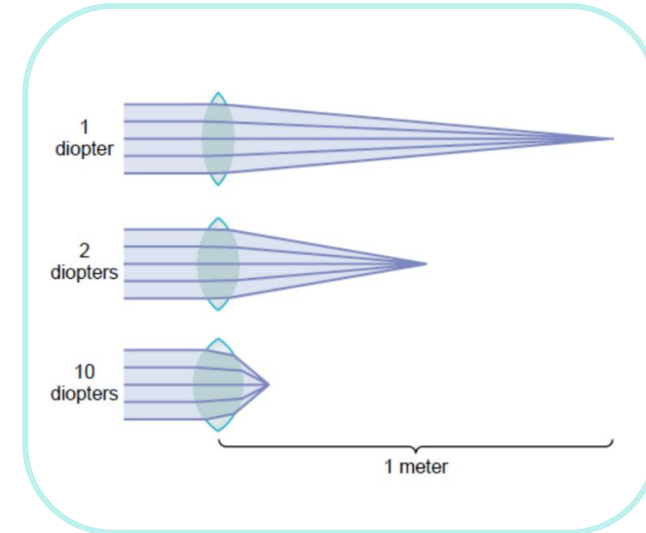


# Lenses: Principles of Optics



## Diopeter:

- Measure of refractive power
- **$R.P = 1 / \text{Principal focal distance in meters}$**
- -Exp / if Principal focal distance of a lens is 25cm, so its  $R.P = 1 / 0.25 \text{ meter} = 4D$
- **The greater the curvature of the lens the greater the refractive power of the eye** (in accommodation, we increase the curvature of the lens)







# Lenses: Principles of Optics

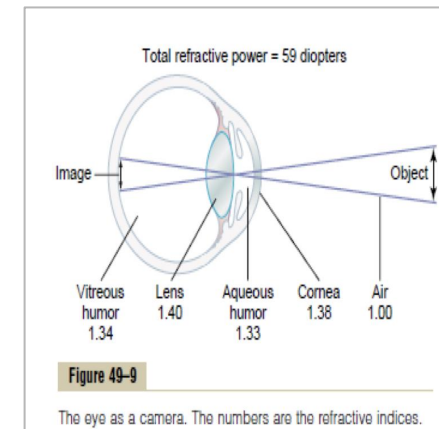
## Emmetropic eye

Emmetropic eye;- **is the normal eye has image on retina, has dioptric power 59-60D**

- It can see all distant objects clearly with its ciliary muscle relaxed & see close objects clearly with ciliary muscles contracted.
- Normal eye = Emmetropia
- Concave lenses "neutralize" the refractive power of convex lenses. Thus, placing a 1-diopter concave lens immediately in front of a 1-diopter convex lens results in a lens system with zero refractive power

## Refractive Media of The Eye

- 1 The interface between air and the anterior surface of **the cornea** (more refractive power)(الانكسار يحصل هنا  $\frac{2}{3}$ )
- 2 The interface between the posterior surface of the cornea and **the aqueous humor**,
- 3 The interface between the aqueous humor and the anterior surface of **the lens of the eye**
- 4 The interface between the posterior surface of the lens And and the **vitreous humor**.
- 5 A total refractive power of 59-60 diopters when the lens is accommodated for distant vision.





# Lenses: Principles of Optics

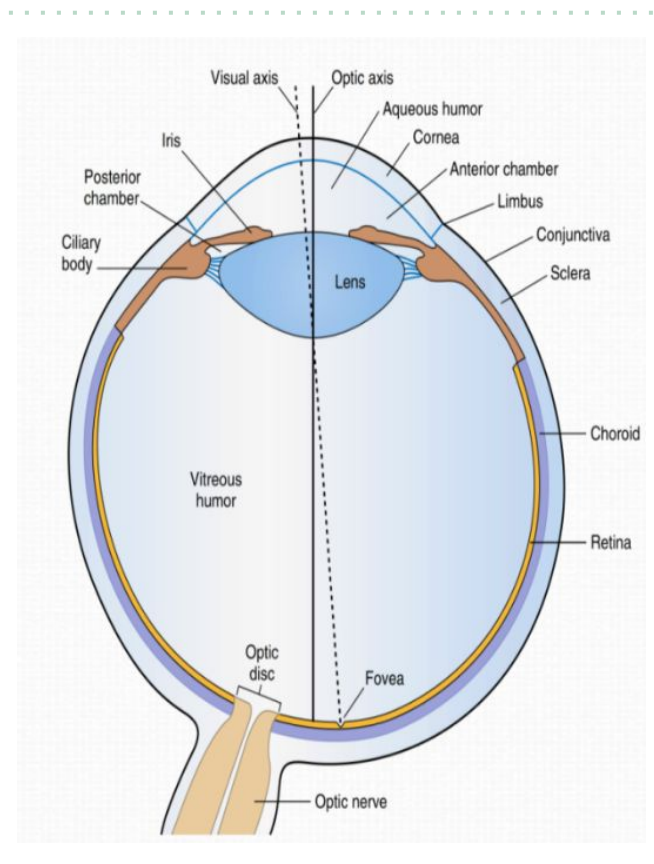
## The cornea

It's dioptric power is **40-45 diopter** at its anterior surface. About two thirds of the 59-60 diopters of refractive power of the eye is provided by the anterior surface of the cornea. -The principal reason for this is that the refractive index of the cornea is markedly different from that of air

-N.B/ The internal index of air is 1

- the cornea, 1.38
- the aqueous humor, 1.33
- the crystalline lens 1.40
- the vitreous humor 1.34.

1





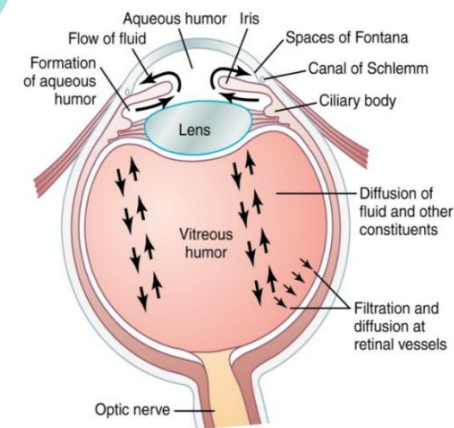
# Lenses: Principles of Optics

## The aqueous humor

It is a transparent, slightly gelatinous (gel-like) fluid similar to plasma)  
Fluid produced by ciliary body (ciliary processes) > to posterior chamber > to pupil > to ant chamber > to canal of schlemm at angle of ant chamber > to veins.

### Functions:

- ❖ Nourishing avascular structures ( cornea ,lens) by an active secretion by ciliary processes.
- ❖ Causes intraocular pressure 10-20mm Hg
- ❖ Produced at a rate of 2-3 microliter/min by active transport of  $Na^+$ , followed by  $Cl^-$  and  $HCO_3^-$  and then osmosis of water
- ❖ Contains many nutrients like amino acids ascorbic acids (vitamin C) and glucose
- ❖ is continually being formed and reabsorbed.
- ❖ obstruction of this outlet leads to increased intraocular pressure , a critical risk factor for **glaucoma**



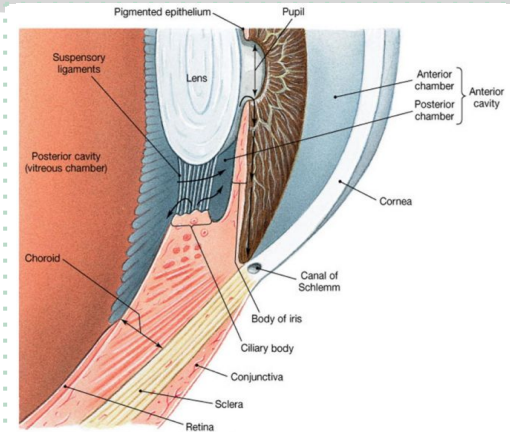


# Lenses: Principles of Optics

## The Lens

Has dioptric power **15-20 D**

- (1/3 refractive power of eye), **more important than cornea**. why?
- **Within the cells of the lens, proteins called crystallins are arranged like the layers of an onion, this makes up the refractive media of the lens**
- **Importance of the internal lens is that, in response to nervous signals from the brain, its curvature can be increased markedly to provide "accommodation"**
- **Lens helps focus images on the retina to facilitate clear vision.**



3

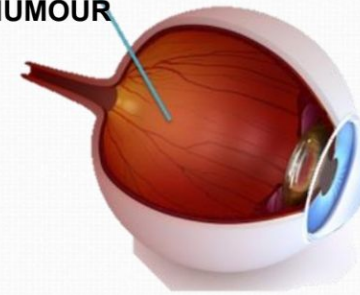
## The Vitreous Humor

Is the transparent, colorless, gelatinous mass

- It fills the vitreous chamber between the **posterior surface of the lens** and the retina
- The vitreous humour is clear and allows light to pass through
  - For nourishing retina & keep spheroid shape of the eye
- **Both water and dissolved substances can diffuse slowly in the vitreous humors**
  - **VITREOUS HUMOUR REMAINS FROM BIRTH**

4

### THE VITREOUS HUMOUR





# Binocular vision

## Binocular Vision:

Are the areas in the centre of visual field of the two eyes in which any object in this area will be seen by both eyes.

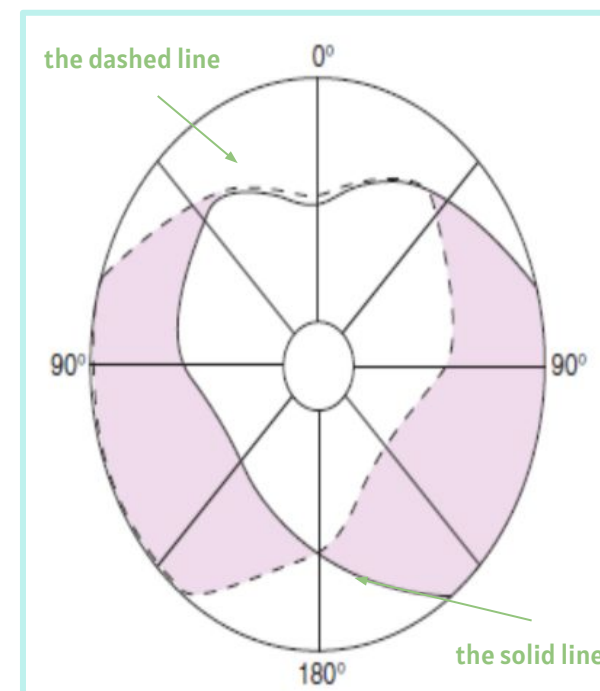
- **BINOCULAR VISION** for:

- Large visual field
- cancel the effect of blind spot
- stereoscopic vision
- one eye lesion does not affect vision

- **Monocular and binocular visual fields:**

- The **dashed** line- encloses the visual field of the left eye.
- The **solid** line, that of the right eye.
- The **common** area (heart-shaped in the center) is viewed with binocular vision.
- The **colored** areas are viewed with monocular vision.

(الملون بالوردي تقدر تشوفه بعين وحده)



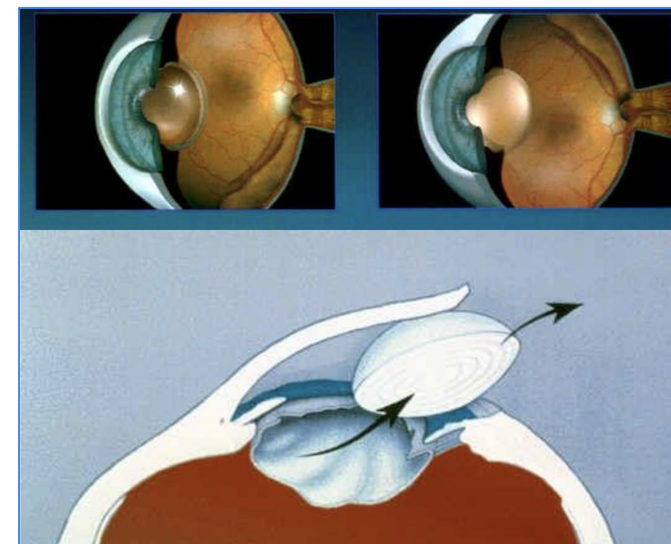
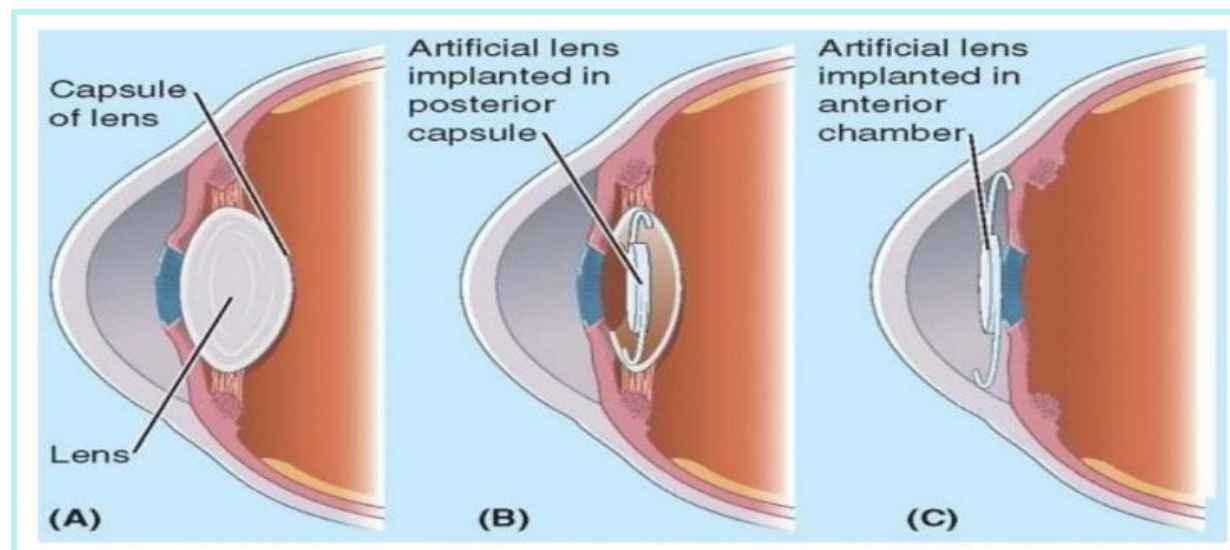


# Cataracts

## Cataracts:

Lens clouds up & the proteins in some lens fibers coagulate to form opaque areas > Must be removed > Typical to replace > lens with implant > Can get clouding repeated > Laser removal \* can be caused by diabetes

- Cataracts occurs in older people.
- It's a cloudy or opaque area or areas in the lens. \*
- cataract impairs vision \*





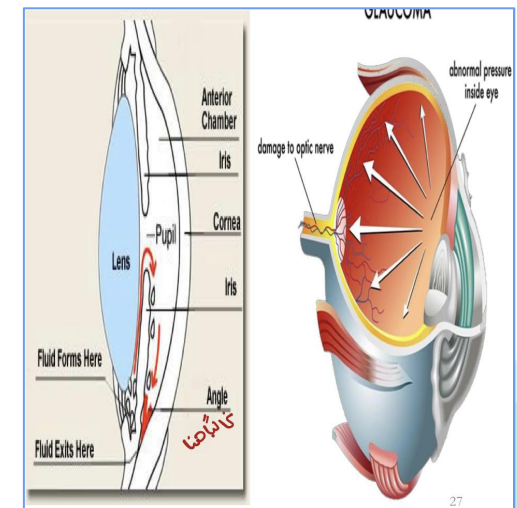
# Glaucoma

- **(Intraocular pressure more than 20 mmHg)**
- **Build up of Aqueous Humor Volume**
- **Obstruction of Aqueous humor outlet leads to increased intraocular pressure in the eye.**
  - pushes the lens backwards into vitreous, which pushes against the retina.
  - compression causes retinal and optic nerve damage that can cause blindness.
- the treatment is **Meds/surgery**
- Glaucoma is an eye condition that develops when too much fluid pressure builds up inside of the eye. The increased internal pressure can damage the optic nerve, which transmits images to the brain. Without treatment, glaucoma can cause blindness within a few years. Glaucoma is most often inherited, meaning it is passed from parents to children. Less common causes of glaucoma include a blunt or chemical injury to the eye, severe eye infection, blockage of blood vessels in the eye and inflammatory conditions of the eye. Glaucoma usually occurs in both eyes, but it may involve each eye to a different extent.\*

**Normal vision**

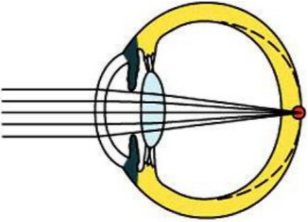
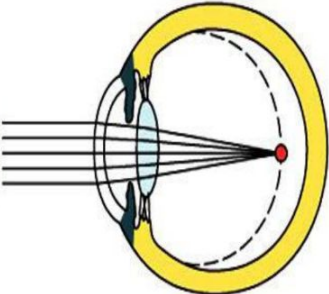


**Glaucoma**





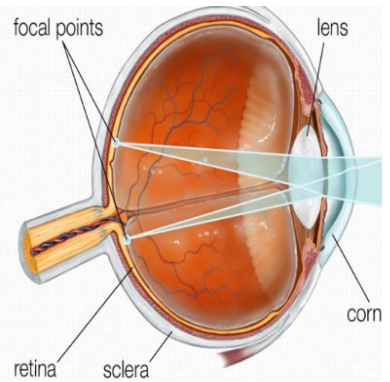
# Errors of Refraction

Error	Description	Correction
<p><b>Hyperopia</b> (hypermetropia-Far sightedness)</p>  <p>(c) Hyperopia</p>	<p>Small/Short eye ball with weak lens system.</p> <ul style="list-style-type: none"> <li>● image Focus is <u>behind</u> retina.</li> <li>● Causes blurred vision.</li> <li>● Continuous accommodation to bring image on retina causes muscular effort on ciliary muscles &amp; prolonged convergence, which will lead to <b>headache</b> and finally squint.</li> <li>● An affected individual has to use accommodation even for distant objects.</li> </ul>	<p><b>Biconvex lens</b></p>
<p><b>Myopia</b> (Nearsightedness)</p>  <p>(b) Myopia</p>	<p>Genetically large eyeball or too much R.P (refractive power) of the lens system <b>or cornea due to its curved surface</b> , or due to long anterior-posterior diameter of the eye.</p> <ul style="list-style-type: none"> <li>● Myopia is thought to be partially genetic in origin. However, there is a positive correlation between sleeping in a lighted room before the age of 2 and the subsequent development of myopia.</li> <li>● In young adults the extensive close work involved in activities such as studying accelerates the development of myopia.</li> <li>● image Focus will be <u>IN FRONT</u> of the retina.</li> </ul>	<p><b>Biconcave lens</b> To diverge rays before strike the lens</p>





# Errors of Refraction

Error	Description	Correction
<b>Astigmatism (انحراف)</b> 	<p>The light rays focus at more than one focal point. Uneven and ununiformed corneal curvature and very rare due to <b>uneven lens curvature</b>. so rays refracted to different foci resulting in blurred vision.</p>	<b>Cylindrical lens</b> Bends light rays in only one plane (a focal line)
<b>Presbyopia</b>	<p>Eye near point recedes by age due to loss of accommodation. Focus behind retina. <b>ciliary muscle weakness</b></p> <p>للي أعمارهم فوق الخمسين مثلاً يصيرو يلبسو نظارات قراءة لانه يصيرلهم</p>	<b>Biconvex lens</b>



# Three Types of Retinal Ganglion Cells and Their Respective Fields

1

## W cells:

- Has small diameter
- sensitive or detecting directional movement in the field of vision, and they are probably important for much of crude rod vision under dark condition

dr: focus on the red text only is very important

2

## X Cells :

- Has a medium size diameter
- Transmission of the fine details and color vision

3

## Y Cells :

- Has the largest diameter and fast conduction velocity
- To Transmit instantaneous & rapid changes in the visual image , give clues that make the eyes move toward the exciting vision.

### In primates a different classification is used:

<b>Parvocellular (P) cells</b>	which project to parvocellular layer of LGB, conducting signal <b>of fine details &amp; colors</b>
<b>Magnocellular(M) cells</b>	which project to magnocellular layer of LGB, and they are <b>high sensitive to low contrast stimuli and to rapid movement visual signals</b>
Melanopsin	send signal to suprachiasmatic nucleus of hypothalamus for control of circadian rhythm



# TEST YOURSELF !

**1- Which one of the following cells carry action potentials to the optic nerve?**

A) Bipolar cells

B) Amacrine cells

C) Horizontal cells

D) Ganglion cells

**2- Which ONE of the following lenses corrects Astigmatism?**

A) Bifocal

B) Convex

C) Cylindrical

D) Concave

**3- Which ONE of the following secretes the intraocular fluid of the eye?**

A) Ciliary processes

B) Iris

C) Cornea

D) Lens

**4- Cause of myopia:**

A) Increase in anterior posterior diameter

B) Loss of elasticity

C) Uniform diameter

D) Short eyeball



**SAQ**

## What is External protection of the eye ?

slide 11

## Mention dioptric power of the eye

Cornea 40-45 D

Lens 15-20 D

Accommodation by lens +12 D

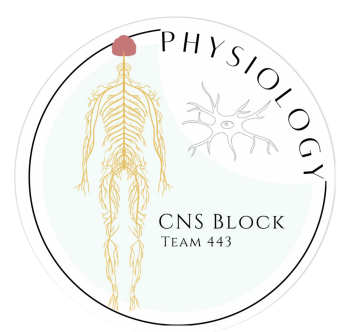
## What are the INNERMOST layer retina ?

1- Photoreceptors

2- Optic disc

3- Macula & Fovea centralis

# Team Leaders



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💡 Special Thanks to Physiology Team441  
💡 Team logo and design was done by Rafan Alhazzani  
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